



Editorial

Who discovered REM sleep?

Michael H. Silber^{1,*}

¹Center for Sleep Medicine and Department of Neurology, Mayo Clinic College of Medicine and Science, Rochester, MN, USA

*Corresponding author. Michael H. Silber, Center for Sleep Medicine, 200 1st Street SW, Rochester, MN 55905, USA. msilber@mayo.edu.

In 1950 Eugene Aserinsky began graduate work at the University of Chicago, reluctantly selecting as his mentor Nathaniel Kleitman, the pre-eminent researcher in the field of sleep. In his very personal account published 46 years later [1], he describes how Kleitman assigned him the task of observing infants' blinking rates during sleep. After months of relatively unsuccessful work, he decided to investigate adult sleep, using the corneo-retinal potential to record eye movements, with remarkable results. He and Kleitman published their seminal paper in *Science* in 1953 [2], describing 3 to 4 nightly periods of saccadic eye movements, increased respiratory rate, and body movements associated with periods of dreaming in 20 adults. They subsequently published a more detailed description in 1955 [3], as well as reporting in the same year similar cycles in sleeping infants [4].

In his account of the discovery [1], Aserinsky states that Kleitman had only a "tangential role" "on the periphery of this particular study." Almost unbelievably, he states that he had "misgivings about giving Kleitman any authorship at all," despite Kleitman being his supervisor and thesis advisor! He states that he had "never taken kindly to working with others" and that he was either the sole or senior author in his first 30 publications. It is not known what Kleitman, who was alive but 101 years old at the time of Aserinsky's account, would have made of these allegations.

In 1952 William Dement, then a medical student, joined Kleitman's laboratory and continued as a research fellow after graduation. In his 1999 book, *The Promise of Sleep* [5], Dement states that he made up the name of rapid eye movement (REM) sleep as a "fifth distinct stage." While this is likely correct, the origin of the term is somewhat more nuanced. Aserinsky and Kleitman were the first to describe eye movements as "rapid, jerky" in their 1953 paper [2] and used the term "rapid eye movement periods" in their 1955 description [3]. Dement and Kleitman used the same terminology, but not stage REM, in their detailed account of the stages of sleep published in 1957 [6]. Dement served on the committee that constructed the classic 1968 sleep staging manual edited by Rechtschaffen and Kales [7] in which the term "stage REM" is specifically used. The manual cites the 1957 paper [6], as well as acknowledging the influence of a prior manual presented by Dement at the APSS meeting of 1962.

Despite these minor controversies, it would appear well-established that Aserinsky and Kleitman discovered REM sleep with later contributions by Dement. But in this issue of *SLEEP*, Dr. Kristina

Denisova, an associate professor of psychology and neuroscience at the City University of New York, translates and comments on a 1926 Russian study which she plausibly contends is a description of the state later called stage REM sleep [8]. In the study, a series of infants were observed during sleep using a pneumograph to measure breathing and visual observations to assess body movements and movements of the eyelids and eyeballs under the lids. The authors report periods of variable breathing, increased body movements, increased heart rate, and "side to side and down(wards)" eye movements observed through partially open lids, with these cycles commencing at sleep onset and repeating themselves at an average periodicity of 50 minutes. Dr. Denisova astutely compares these observations to those of Kleitman and Aserinsky in their 1955 paper on infant sleep, noting many similarities.

Dr. Denisova notes that Kleitman and Aserinsky cite the 1926 Denisova and Figurin paper in their 1955 publication on infant sleep [4], but it is unclear if the study played any role in influencing their research. Their only mention of the paper is to reference a general statement in their introduction, without any further elaboration. They do not cite the older paper in their seminal 1953 account [2], possibly because they were unaware of it at that time or because Denisova and Figurin studied predominantly infants. Perhaps Aserinsky is correct in asserting that Kleitman showed only peripheral interest in his discovery and therefore did not peruse the 1926 paper in any detail. However, Kleitman, who was born in what is now Moldova and could read five languages including Russian [9], would likely have been conversant with the paper's contents. In his 1963 revised edition of his classic text, *Sleep and Wakefulness* [9], Kleitman discusses the paper in a little more detail, noting that Denisova and Figurin "established a 50-minute cycle of alternately slow and fast breathing during sleep in infants... (with) a number of accessory phenomena such as increased heart rate and movements of the body, hands, head, and eyelids." But there is no mention of their observation of horizontal and vertical eye movements. Any attempted reconstruction of their approach to the Russian study is speculative, but the brevity of their allusions to it remains somewhat perplexing.

So should Denisova and Figurin be credited with the discovery of REM sleep, instead of the distinguished American investigators? I would suggest that partial identification of a phenomenon is insufficient to get full credit for a scientific discovery. A broader understanding of the underlying mechanisms and significance

of the phenomenon is necessary, preferably with extended follow-up studies. An example from our own field of sleep medicine is in an extensive monograph on narcolepsy published in 1934 by Lumen Daniels, a fellow in neurology at Mayo Clinic [10]. Among his 147 patients, Daniels identified two who were obese with short, fat necks, and long soft palates who snored loudly and “almost choked” at times in the night. However, he did not understand the significance of his observations nor did he pursue them further, and no one would suggest that he should be credited with the discovery of obstructive sleep apnea.

This approach can be applied to the 1926 Denisova and Figurin paper [8], in which they clearly delineated many of the characteristics of REM sleep. First, the investigators identified the phenomenon only in infants. They studied four adults and did not identify any similar cycles. Second, through no fault of their own, they did not have EEG or EOG available, as Hans Berger only identified the EEG in 1929 [11]. Third, they did not identify the crucial relationship of the active cycles to dreaming. Fourth, they did not understand the physiologic processes underlying their observations and speculated that the phenomena were due to “age-related peculiarities.” Finally, there is no evidence that they pursued that discovery in further research. In contrast, Aserinsky and Kleitman in their classic 1953 paper [2] identified phenomena they observed through electrophysiologic techniques in adults, distinguished the “rapid, jerky eye movements” from previously observed slow eye movements, and woke their patients determining that they were dreaming. In their subsequent 1955 papers [6], they confirmed the findings in infants, and named the phenomenon “rapid eye movement periods.” In later papers, Aserinsky, Dement, and Kleinman further elaborated on this separate stage of sleep [3,4,6], paving the way for the development of modern sleep medicine.

Thus I suggest we should continue to honor Aserinsky and Kleitman as the predominant discoverers of REM sleep. However, Dr. Denisova’s discovery and analysis of the earlier Russian paper is commendable and add a deeper dimension to our understanding of the rich history of the complex way that sleep science and medicine have evolved.

Disclosure Statement

Financial disclosure: Dr. Silber has no financial disclosures to report.

Nonfinancial disclosure:

Dr. Silber reports no conflicts of interest.

References

1. Aserinsky E. The discovery of REM sleep. *J Hist Neurosci*. 1996;**5**(3):213–227. doi: [10.1080/09647049609525671](https://doi.org/10.1080/09647049609525671)
2. Aserinsky E, Kleitman N. Regularly occurring periods of eye motility, and concomitant phenomena, during sleep. *Science*. 1953;**118**(3062):273–274. doi: [10.1126/science.118.3062.273](https://doi.org/10.1126/science.118.3062.273)
3. Aserinsky E, Kleitman N. Two types of ocular motility occurring in sleep. *J Appl Physiol*. 1955;**8**(1):1–10. doi: [10.1152/jappl.1955.8.1.1](https://doi.org/10.1152/jappl.1955.8.1.1)
4. Aserinsky E, Kleitman N. A motility cycle in sleeping infants as manifested by ocular and gross bodily activity. *J Appl Physiol*. 1955;**8**(1):11–18. doi: [10.1152/jappl.1955.8.1.11](https://doi.org/10.1152/jappl.1955.8.1.11)
5. Dement WC, Vaughan C. *The Promise of Sleep*. New York: Delacorte Press; 1999.
6. Dement W, Kleitman N. Cyclical variations in EEG during sleep and their relation to eye movements, body motility, and dreaming. *EEG Clin Neurophysiol*. 1957;**9**:673–690.
7. Rechtschaffen A, Kales A, eds. *A Manual of Standardized Terminology, Techniques and Scoring System for Sleep Stages of Human Subjects*. Bethesda, Maryland: National Institute of Neurological Diseases and Blindness, Neurological Information Network; 1968.
8. Denisova K. English translation of the first study reporting cyclical periods of increased respiration and eye and body motility during sleep in infants in 1926, with commentary. *Sleep*. 2024;**47**(1):zsad219. doi: [10.1093/sleep/zsad219](https://doi.org/10.1093/sleep/zsad219).
9. Kleitman N. *Sleep and Wakefulness*. Chicago: The University of Chicago Press; 1963.
10. Daniels LE. Narcolepsy. *Medicine (Baltimore)*. 1934;**13**(1):1–122.
11. Berger H. Uber das elektroenkephalogram des menschen. *Arch Psychiatr Nervenkr* 1929;**87**:527–570.